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ABNORMALITIES IN THE CESTODE MONIEZIA EXPANSA. III.

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In Parts I. and II. of this paper (Child, '00) the various abnormalities occurring in *Moniezia expansa* were described, in Part I. those consisting of imperfect and partial proglottids and in Part II. the spiral abnormalities. It now remains to determine the manner in which these various abnormalities arise, and to discuss the significance of the facts observed.

As is clear from preceding descriptions, there is not the slightest evidence that any of the form-variations of the proglottids appear after development of the proglottid is begun. The degree of differentiation of all parts of an abnormal proglottid is the same, and corresponds to its position in the chain. All the various kinds of form-variations occur in the youngest distinct proglottids. These facts lead to the conclusion that the variations in form appear at the time when the proglottid is formed; that imperfect and partial proglottids and spiral series take their origin in that part of the body in which the causes that lead to the formation of proglottids are at work. That is to say, variations in form are the result of variations in the original formative processes, not the result of modification in the form of structures already established.

Since this is the case, the process of formation of the normal proglottid may be expected to throw some light upon the factors concerned in the formation of abnormalities. The first part of this paper is devoted to a description of the normal method of proglottid-formation.

The figures are all semi-diagrammatic, but in the figures of sections the nuclei of the parenchyma were drawn in with the

camera, and thus correspond as nearly as possible in number and position with those in the actual sections. The subcuticular layer, however, is represented schematically by stippling.

1. Structure of the Neck-Region and Formation of Proglottids.

Behind the scolex there is a region some five to eight millimeters in length, commonly known as the neck, in which no division into proglottids is visible externally.

A few words regarding the structure of the body in this region will render the following description somewhat clearer.

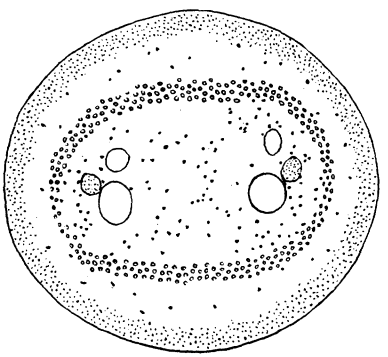


Fig. 42.

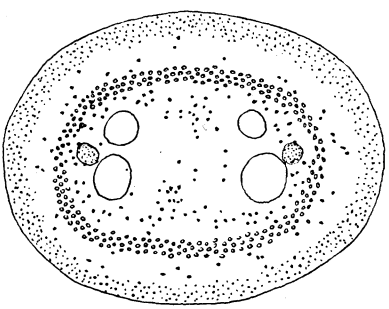


Fig. 43.

Figs. 42 and 43 are transverse sections through the region between the scolex and the point where distinct proglottids appear. Fig. 42 is taken from a section near the scolex, Fig. 43 from one further back. The lines 42 and 43 in Fig. 46 (p. 98) indicate respectively the approximate levels of the two sections. The proglottids are just becoming visible externally at the posterior end of Fig. 46.

The outer cuticular membrane is indicated by the line bounding the figures. Beneath this is a cellular layer, the subcuticular layer, with rather closely packed nuclei, indicated schematically in the figures by the stippled region beneath the cuticle. At this stage of development the nuclei appear to lie in more than one row. Beneath this cellular layer is found the parenchyma. The portion of the parenchyma external to the longitudinal muscles I have, for convenience, designated as the peripheral parenchyma

(Rindenschicht of various authors). This contains a few widely scattered nuclei. The most conspicuous muscle-layer at this stage is the well-developed longitudinal muscle-layer indicated in the figures. Other muscles are not shown. Within the muscle-layer the central region of the proglottid is occupied by parenchyma. This portion of the parenchyma surrounded by the longitudinal muscle layer may be called the central parenchyma (Mittelschicht). In it lie the large ventral and the smaller dorsal nephridial canals and the lateral nerve cords.

In the central parenchyma the nuclei are more abundant than

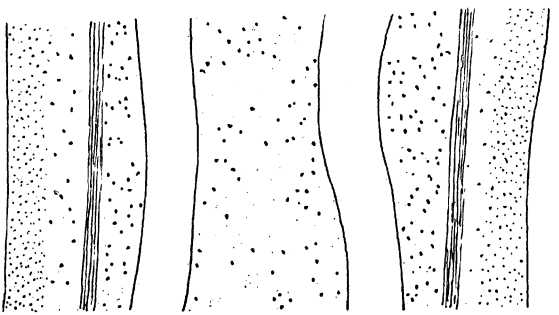


FIG. 44.

in the peripheral layer, and, as the figures show, they are rather more numerous in the outer parts of the parenchyma, especially between the nephridial canals and the muscle-layer.

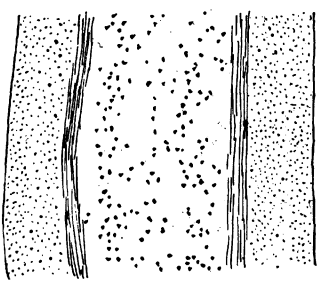


FIG. 45.

The two longitudinal sections, Figs. 44 and 45, show the same structures. Fig. 44 is drawn from a frontal section about half way between the scolex and the first distinct proglottids in the plane of the line 44, Fig. 53 (p. 103). Here the nuclei of the

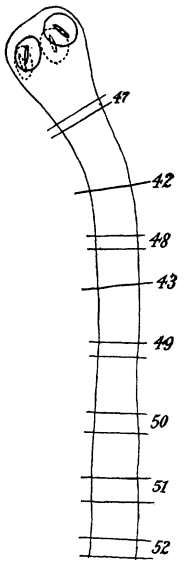


FIG. 46.

central parenchyma are seen to be more abundant at the two sides between the nephridial canals and the muscles. In Fig. 45, which is taken from a sagittal section in the median line (see line 45, Fig. 53, p. 103), the nuclei of this region are seen to be most abundant near the outer boundary of the central parenchyma.

The earliest stages of the growth of the body occur in the neck-region and the proglottids appear at the posterior end of the neck.

Consideration of the method of proglottid-formation requires, therefore a study of the neck-region, and to this the following paragraphs are devoted.

The series, Figs. 47–52, show parts of the neck and the region just posterior to it, viewed as transparent objects. The region of the neck represented by each figure is indicated approximately in Fig. 46 by the numbered areas enclosed by parallel lines, the number in each case corresponding to the number of the figure. All six figures were drawn from a single preparation, a whole mount of scolex and neck-region, which was fixed in the extended condition while slightly flattened between two slides. The longitudinal muscle-layer is indicated by parallel broken lines, and the nephridial canals are drawn in. Nuclei and their general distribution are represented by the stippling.

FIG. 47.

In Fig. 47, which shows the region at the posterior end of the scolex itself, the nuclei in the region between the nephridial canals and the longitudinal muscles, where they are most abundant, show faint indications of an arrangement in parallel bands, groups, or zones extending transversely. The groups of the two sides of the body appear to be entirely separate from each other,

the inner end of each band or zone lying in the region of the nephridial tubes. The groups or aggregations of nuclei are so indefinite that it is difficult to count them or to determine whether they correspond on the two sides of the body. The nuclei of the region between the nephridial tubes show no definite grouping.

FIG. 48.

Fig. 48, taken further posteriorly (see Fig. 46), shows a similar arrangement of the nuclei within the longitudinal muscle layer.

This peculiar arrangement of nuclei in this region varies somewhat as regards distinctness in different specimens. It can always be made out in preparations which are well extended longitudinally, but in contracted specimens the nuclei are so massed together that it often disappears. The examination of a large number of specimens has, however, satisfied me that it is a normal characteristic of this region.

Fig. 49 is taken from a point near the posterior end of the neck region (see Fig. 46) and shows bands of nuclei extending across the central parenchyma, the first distinct evidences of pro-

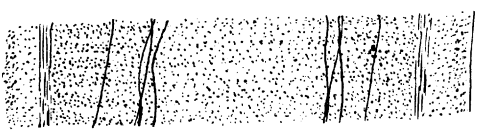


FIG. 49.

glottid-formation. The arrangement of the nuclei in these bands is probably due not so much to migration of the nuclei as to more rapid multiplication of certain of them, thus forming aggregations. It may be, however, that migration does occur to some extent. From this point on, these parallel bands of nuclei become more and more distinct and it is clearly evident that they represent the proglottids.

In Fig. 50 an arrangement of nuclei into transverse bands extending across the central parenchyma is still more distinct and

the bands are broader than in Fig. 49. As yet, however, there is no trace of the inter-proglottidal furrows upon the margins or surfaces of the body, and indeed the grouping of the nuclei does not extend into the peripheral parenchyma at all.

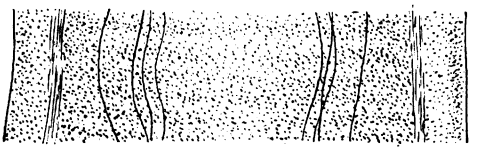


FIG. 50.

Fig. 51 shows a still later stage in the process of proglottid-formation. The bands of nuclei are still broader and more distinctly marked in the middle region of the body, though the nuclei are still more abundant in the lateral regions of the central parenchyma. It is evident that the number of nuclei is increasing. One marked advance in the development is noticeable here, viz., the arrangement of the nuclei in the peripheral parenchyma in groups corresponding to those formed within the longitudinal muscles. It is evident that this grouping is gradually extending toward the surface of the body, though it has not yet reached it.

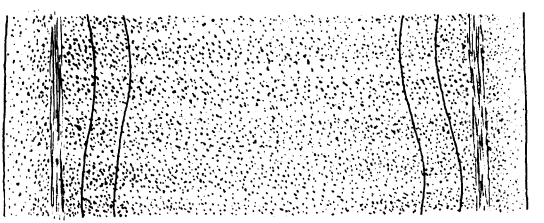


FIG. 51.

In other words, there are in this region of the neck localized regions of growth, or regions in which the nuclei multiply more rapidly than in the intervening, regions and now these areas of more rapid growth are gradually extending toward the surface of the body. All of the figures being drawn to the same scale, it is evident that the growth in width of the body has begun.

In Fig. 52 the proglottids are well defined and their boundaries are indicated upon the surface by shallow furrows. The body is

increasing in width and each proglottid is growing longer as well. Even at this stage the nuclei are seen to be more abundant in the region of the nephridial canals.

The Figs. 49–52 render it sufficiently evident, I think, that each proglottid is simply an area of relatively rapid growth in the parenchyma. The growth first becomes evident in the lateral regions of the central parenchyma, *i. e.*, between the nephridial canals and the longitudinal muscles, where, as was noted above, the nuclei are most abundant. It gradually extends from each side across the middle region of the body, thus forming a zone, which at first includes only the central parenchyma, but gradually extends to the peripheral parenchyma. At last the growth be-

FIG. 52.

comes evident upon the surface, the regions in which it occurs becoming convex as might be expected. At this stage then each proglottid represents a transverse slice of the body which is increasing in size more rapidly than the intervening regions, which therefore become marked as furrows. The furrows are not to be regarded as constrictions, but simply as marking the areas where growth in the transverse direction is least rapid.

The important points in the process are as follows: Each proglottid arises as two distinct aggregations of nuclei, one on either side of the body, which later extend toward the median line and become continuous, and still later extend to the surface or at least to the outer layer of the body.

In Figs. 47 and 48, as noted above, there are traces of a transverse arrangement of the nuclei in the lateral regions of the central parenchyma into bands or groups. The question at once arises as to whether these groups represent the earliest stages of the proglottids, or whether they are connected with some de-

tail of the structure of the neck-region. The evidence on this point is gathered and discussed in the following paragraphs, in which the structure of the neck-region and the early proglottid is examined in detail.

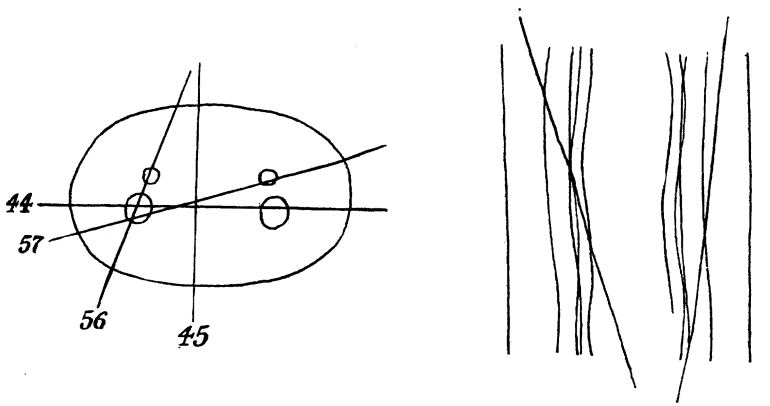
Attention may once more be called to the fact that in the figures of sections the individual nuclei, except those of the subcuticular layer, were drawn in with the camera, so that the arrangement of the nuclei seen in the figures corresponds as closely as possible to their arrangement in the actual section. As the nuclei are distinct and not very numerous, the figures are probably free from serious inaccuracies in this respect.

First of all in this connection, the two transverse sections, Figs. 42 and 43 (p. 96), require renewed consideration. These sections lie in the plane of the aggregation of nuclei and consequently do not show them. Incidentally it may be mentioned, however, that in following through a series of transverse sections from the neck-region, the nuclei between the nephridial canals and the longitudinal muscles are more abundant in some sections than in others and that a certain, not very marked periodical recurrence of the two conditions can be made out. The point of immediate interest shown in Figs. 42 and 43 is the greater abundance of nuclei in the lateral regions of the central parenchyma. In both figures the regions contain numerous nuclei distributed with more or less uniformity, while the region between the two pairs of nephridial canals, though showing some more or less distinct aggregations, contains in general fewer nuclei. This point confirms the evidence afforded by the study of whole mounts, viz., that the nuclei appear to be more abundant in the lateral regions of the central parenchyma than elsewhere when viewed from either surface. Of course in whole mounts the distribution of nuclei in the central parenchyma is more or less marked by the subcuticular peripheral nuclei.

Longitudinal sections are necessary to show the groups of nuclei. The frontal section, Fig. 44 (p. 97), is taken from near the anterior end of the neck. It passes through the ventral nephridial canals. The plane of the section is indicated by the line 44 in Fig. 53. The nuclei of the central parenchyma are seen to be much more abundant lateral to the nephridial canals

than between them. Moreover, an indistinct arrangement in groups of the nuclei of these lateral regions of the central parenchyma does appear, especially on the left side. The groups of nuclei are so illy defined in the preparations in toto, where the whole dorso-ventral thickness of the central parenchyma is seen, that it can scarcely be expected that a section only a few micra (7) in thickness, and thus containing only a small part of the total number of nuclei in a given group, should show the arrangement any more clearly. The nuclei of the peripheral parenchyma are very few in number and scattered, showing no indication of any arrangement in groups corresponding to those of the central parenchyma.

In Fig. 45, a sagittal section near the median plane, the nuclei are seen to be most abundant in two regions, near the outer mar-



FIGS. 53–54.

gins of the central parenchyma, appearing in the section as two longitudinal bands of nuclei, which are in reality sections of two layers of nuclei, a dorsal and a ventral layer. These layers were indicated indistinctly in the transverse sections shown in Figs. 42 and 43. The tendency to aggregation of the nuclei into groups which is present in the lateral regions of the central parenchyma is not visible here, or at least not sufficiently distinct to appear in the section. As regards this point the section confirms the observations on the whole mounts. The region from which this section was taken corresponds approximately to the region from which Fig. 48 was drawn, being probably a little posterior to it.

In Fig. 48 the groups of nuclei, though visible laterally, do not extend to the median plane. It should be noted that the parenchyma-nuclei are more abundant in Fig. 45 than in Fig. 44, thus indicating that multiplication of the nuclei is occurring even in the neck-region anterior to the point where the proglottids be-

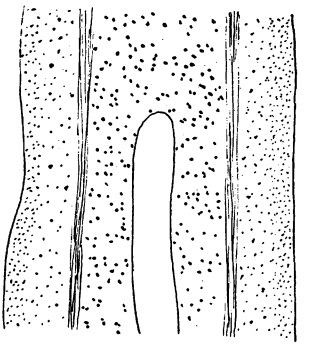


FIG. 55.

come distinct, for Fig. 45 is taken some distance posterior to Fig. 44.

Fig. 55 is drawn from a nearly sagittal section near the posterior end of the neck region. Its plane is indicated by the line

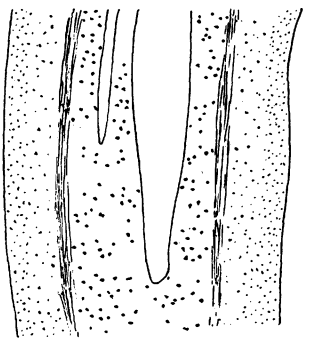


FIG. 56.

55 in Fig. 54. The ventral nephridial canal lies partly in the plane of the section. Here again an aggregation of the nuclei into groups is visible, especially in the lower portion of the figure.

Fig. 56 represents another oblique section which cuts both

nephridial canals. It is taken from about the same region of the neck as Fig. 55, but from another individual. The plane of this figure is represented approximately by the line 56 in Fig. 53. In this figure the grouping of the nuclei is more distinct than in the other longitudinal sections.

These figures represent sections of approximately the same region as is shown in Fig. 49, *i. e.*, a region in which the proglottids first become recognizable. The groups of nuclei represent, therefore, the early stages of what we know to be proglottids, and yet the chief differences between these figures and Fig. 44 consist in the larger number of nuclei and a greater degree of distinctness in the groups of the former figure.

At this point the relation of the lateral groups or zones of nuclei in the anterior neck region to the proglottids requires consideration.

As is evident from the facts stated above, the distinct proglottid extending across the body and marked by a convex contour of the surface appears first at a considerable distance behind the scolex. All through the neck region, however, occur the indistinct groups of nuclei in the lateral regions of the central parenchyma, and, when the proglottids form, their earliest stages appear to arise from the groups.

If these groups represent the earliest stages of proglottid-formation, then the proglottid must be laid down just behind the scolex and pass backward through the neck-region in consequence of the formation of new proglottids in front of it, until finally its development reaches a stage where it becomes visible externally. If the groups of nuclei anterior to the regions where proglottids first become recognizable as bands of nuclei extending over the nephridial canals toward the median plane, do not correspond to proglottids, they must be due to some other features in the structure of the neck. In this case, the neck constitutes an unsegmented region, which gradually becomes marked off into proglottids.

The facts favor the second view. In the first place, the groups of nuclei are just as distinct immediately behind the scolex as they are further back (*cf.* Figs. 47 and 48), *i. e.*, no development occurs in them except perhaps a slight increase in the number of

nuclei until the region is reached where the proglottids become distinguishable. And secondly, I have found similar groups of nuclei in the neck-region of other cestodes, but in a number of cases they did not correspond to proglottids, but a number of them, four or five or perhaps more, were included within a single proglottid when it formed, and a still higher number were found in older proglottids. The examination of *Moniezia expansa* alone might lead to the acceptance of the first of the two alternatives stated above, for when the proglottids do appear they are aggregations of nuclei in the lateral regions of the central parenchyma, of about the same size as the other groups. This comparison with other forms shows that the indistinct grouping of nuclei throughout the neck region has nothing to do with the formation of proglottids. The existence of the groups is probably due to the more or less regular repetition of the dorso-ventral muscles, which are most abundant in the lateral regions of the central parenchyma, and perhaps also in part to the arrangement of the circular muscles. Between the muscles the nuclei of the undifferentiated parenchyma are aggregated into groups. Such an arrangement seems to be visible in some sections, but in others does not appear distinctly.

I have considered this point rather fully because in *Moniezia* the resemblance of the nuclear groups to the early stages of the proglottids is very close.

Returning to the consideration of the forming proglottid, we find that after it becomes visible as a zone of nuclei extending across the central parenchyma, a continuous increase in size in all directions occurs. Some of the features connected with this process of growth require attention here.

In the early stages of the proglottid, before the furrows have become visible on the surface of the body, the parenchyma-nuclei are multiplying very rapidly. Fig. 51 shows the general appearance at this stage, and Fig. 57 is a section of the same stage in the plane of the line 57 in Fig. 53. Here the nuclei of the peripheral parenchyma are just beginning to appear in groups, corresponding in position to the lateral regions of the proglottids in the central parenchyma. Although in whole mounts the boundaries of the proglottids are well marked, sections

show them less clearly. It is interesting to note that the grouping of the nuclei in the peripheral parenchyma appears first in the lateral regions as represented in Fig. 57. Sagittal sections of this stage near the median plane show no grouping of the peripheral nuclei there, although in the central parenchyma the boundaries of the proglottids are quite distinet. Here again the earliest

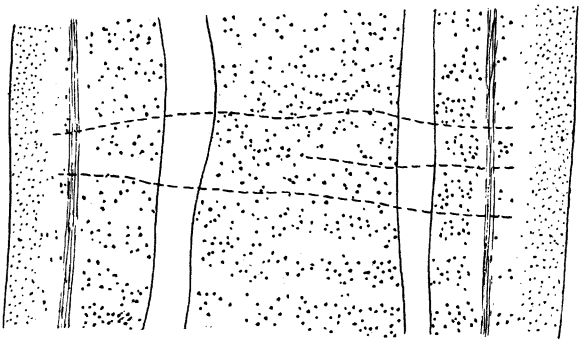


FIG. 57.

stages of development appear near the main nerve-cords and extend gradually to the other parts.

A little later the boundaries of the proglottids become visible on the surface (Fig. 52), and sections at this stage show still further increase in the number of nuclei, especially in the central parenchyma. Fig. 58 represents a sagittal section near the median line. The furrows are beginning to appear on dorsal and ventral surfaces. The outlines of the proglottids are distinct within the central parenchyma and the transverse nephridial canals have appeared. The scarcity of nuclei in the peripheral parenchyma is noticeable, but the few present are more or less distinctly grouped.

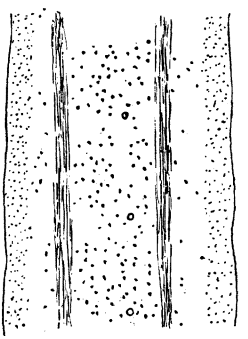


FIG. 58.

A somewhat later stage is represented in the frontal section, Fig. 59. Here the subcuticular cells, which are represented schematically by the dotted region at the margin, have become indistinctly grouped, the spaces between the groups corresponding to the inter-proglottidal furrows. The

peripheral parenchyma-nuclei, though few, are grouped in the proglottids.

Now the proglottid is completely established as a localized region of growth. Later changes which occur lead to some alteration in the shape and proportions of various parts and to the differentiation of various organs within the proglottid.

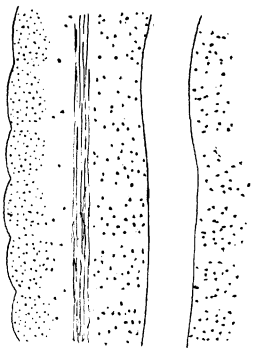


FIG. 59.

In some Cestodes, including *Moniezia*, the longitudinal nerve-cords are connected by a series of transverse proglottidal commissures and other proglottidal nerves are also present. The development of this proglottidal nervous system has been investigated but little, although it is certainly a field of considerable interest. The time at which the nerves appear, their relation to the formation of other parts of the proglottid and themanner of their differentiation are all difficult but important problems.

Tower ('00) has described and figured the origin of the transverse commissures in the neck-region of *Moniezia* (Fig. 1, Taf. 21). Mr. Tower has had the kindness to inform me personally that the folds along the margins of the neck in this figure are not intended to represent the outlines of proglottids but are merely the folds resulting from contraction. He finds that the transverse commissures begin to appear before the proglottids are distinct, but he has not been able to discover any great degree of regularity in the order of their appearance. The first traces of these commissures appear almost immediately behind the scolex, but their formation is not completed until the stage where the proglottids begin to be visible. It is possible, as Tower himself admits, that further study might show a much greater regularity in the development of these commissures.

The point in Tower's figure where the first traces of the commissures appear is certainly far anterior to the region in which the proglottids become distinct, *i. e.*, the commissures are apparently the first of all the proglottidal structures to appear.

The study of the neck-region of *Moniezia* brings to light a

number of facts which possibly indicate a close relation between the appearance and early development of the proglottids and the nervous system. The figures of whole mounts (Figs. 47–52) and of transverse and longitudinal sections through the neck region (Figs. 42, 43, 45) show that the earliest aggregations of the parenchyma-nuclei occur in the region in which the lateral longitudinal nerve-cords lie, and that growth of the proglottids follows the lines which the transverse dorsal and ventral commissures must take as they develop.

In the transverse section, Fig. 43, the nuclei of the central parenchyma are mostly situated in an indistinct ring around the outer margin of the central parenchyma. In Fig. 42, from a more anterior region, this arrangement is less clearly marked. In the longitudinal sagittal section near the median plane (Fig. 45), which is taken from a region posterior to Fig. 43, the same arrangement, or more rapid multiplication of the nuclei is evident in the outer region of the central parenchyma, *i. e.*, in the region which the dorsal and ventral portions of the nervous system occupy.

In general it is evident then that the multiplication of the parenchyma-nuclei occurs most rapidly in regions of the body about the nervous system.

Too little is known regarding the arrangement and development of the proglottidal commissures and nerves in other Cestodes to enable us to determine whether the proglottidal system appears before the proglottids become distinct.

A number of authors have described the nervous system of the proglottids of various cestodes, but little attention seems to have been paid to the region of formation. It seems extremely probable, moreover, that our knowledge of the proglottidal system is incomplete as regards most cestodes. The difficulty of distinguishing with certainty the nervous tissue, not the lack of interest in the subject, is responsible for this condition. Branches arising from the longitudinal nerves have often been mentioned and among the later writers upon the subject a number (Koehler, '94; Scheibel, '95; Lühe, '96; Cohn, '98), have discovered in various forms more or less complex systems of commissures between the longitudinal nerves, sometimes forming a highly developed net-

work. So far as I am aware, the only account of the development of this system is the one given by Tower ('00).

Lühe ('96) and Cohn ('98) have stated that in *Ligula*, where the reproductive organs are repeated but the body shows no segmentation, and in *Schistocephalus*, a segmented form, systems of ring-like and radiating transverse commissures connect the numerous longitudinal nerves. The two sets of commissures always occur together, but are said not to be segmentally arranged. Nothing is known, however, of the development of these commissures, and indeed it is not even certain that other nerves do not exist.

Mr. Tower has very kindly informed me that in abnormal proglottids of *Moniezia* the nervous system was not normally arranged. Unfortunately his notes, drawings, and preparations were destroyed by fire.

It appears then from the little we know of the nervous system of cestodes, and its development in the proglottids, that the system of commissures makes its appearance very early in the history of the proglottid. Tower's account of the nervous system in the neck-region of *Moniezia* renders it very probable that the proglottidal commissures constitute the earliest visible indications of proglottid-formation. As noted above, the nuclei of the central parenchyma in the neck are more abundant in the region of the lateral nerve-cords and in a dorsal and ventral layer which corresponds closely in position to the region occupied by the dorsal and ventral parts of the nervous system. Each proglottid begins to form in two separate parts, one in the region of each lateral nerve-cord; these two parts extend toward the center and unite, *i. e.*, they follow in general the same course of development as do the dorsal and ventral transverse commissures (Tower '00, Fig. 1, Taf. 21). A little later the process of proglottid-formation extends to the peripheral parenchyma; the small nerves extending toward the surface of the body appear, according to Tower, somewhat later than the commissures. Still later in the history of the proglottid the genital organs appear. Tower found certain nerves which he designates as genital nerves, and states that these appear later than the other portions of the nervous system. All of these facts certainly indicate a close connection between the development of the nervous system and that of the proglottid.

It would be premature to attempt with the few facts available to reach a final conclusion with respect to the relations of the two processes. There are three possibilities to be considered: the localization of growth and the formation of proglottids may be the result of the appearance of the transverse nerves and commissures and other parts of the proglottidal system; the development of the nervous system may be the result of the appearance of proglottids; or lastly, both may be effects of a common cause. Which of these three possible views is correct, it is impossible at present to decide. If the first of the three be accepted and it be admitted that some stimulus from the parts of the nervous system as they develop leads to the formation of a proglottid, an explanation is afforded of the first appearance of the proglottid as two groups of nuclei on opposite sides of the body, of the position of these groups, of the direction of their growth and of the order of development of the various parts of the proglottid. It would be out of place here to discuss the influence of the nervous system on growth, differentiation, and regeneration in general, but that such an influence has been found to exist in many cases cannot be denied.

If we accept either of the other two possibilities, no explanation of the observed method of proglottid-formation can be given at present.

The development of the nervous system and the process of proglottid-formation in different cestodes certainly offers a most interesting field for research.

2. The Growth of the Proglottids.

The further history of the proglottid concerns its growth in size, various alterations in shape and the development of the genital organs. It is beyond the scope of this account to enter into

Figs. 60.

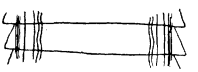


Fig. 61.

the details of the formation of the genital organs, but some features of the growth require consideration.

Figs. 60–63 are outline drawings of the form of the proglottid

at various stages of its history. Fig. 63 shows one half of the proglottid. The longitudinal muscles and the nephridial canals are indicated. Examination of this series will show clearly that

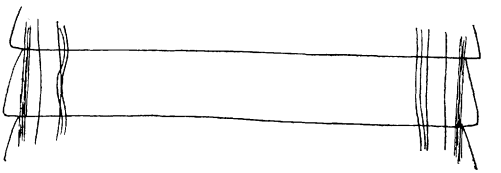


FIG. 62.

almost the whole increase in the width of the proglottid is due to the growth of the central parenchyma, the peripheral parenchyma forming little more than the posterior extensions at the margins.

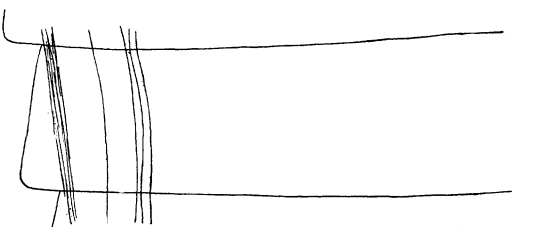


FIG. 63.

In the growth in thickness of the body, *i. e.*, in the dorso-ventral direction, the central parenchyma is not so markedly predominant. The three regions seen in a sagittal section preserve

FIG. 64.

FIG. 65.

FIG. 66.

FIG. 67.

much the same proportions during the growth of the proglottids (Figs. 64–70). In this series Figs. 66 and 67 show respectively the contracted and extended conditions in proglottids of the same age. Figs. 68 and 69 show similar conditions in a later stage. Fig. 70 is from a nearly "ripe" proglottid. In this series it is seen that the peripheral parenchyma has undergone about the

same amount of growth here as at the lateral margins, while the central parenchyma shows very little relative increase in thickness.

In general, the central parenchyma grows chiefly in the lateral and longitudinal directions, the actual increase in thickness being much less than the increase in other dimensions and relatively very slight. The growth of the peripheral parenchyma increases

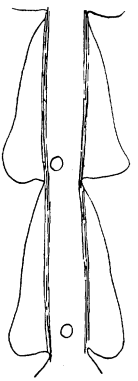


FIG. 68.

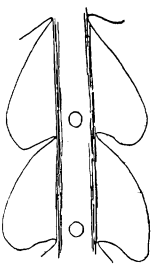


FIG. 69.

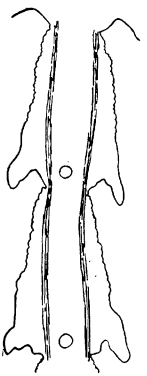


FIG. 70.

in amount from the anterior to the posterior end of each proglottid, but is similar about the whole circumference of the body. The first traces of the posterior extensions of the proglottids are seen in Fig. 71, a sagittal section of an early stage. Nearly all the nuclei of the peripheral parenchyma are grouped near the posterior boundary of each proglottid, indicating that growth is more rapid there than elsewhere, and the outlines of the proglottids are no longer regularly rounded, as in Fig. 59 for instance, but show distinctly localized growth in the posterior region.

The above observations upon the origin and growth of the proglottid may be summed up as follows: The whole neck is a region of growth; in the anterior part of the neck the growth is general but posteriorly it gradually becomes localized and thus gives rise to the proglottids. Each proglottid arises as two distinct aggregations of nuclei in the central parenchyma near the lateral nerve-cord. Gradually the intervening portions of the central parenchyma come to show a similar arrangement and a zone of localized growth is formed. This growth next extends

to the peripheral parenchyma and finally becomes visible on the surface in the rounded contour of the proglottid and the furrows marking it off from others. Later growth, while including all parts of the proglottid, is greatest in amount in the central parenchyma. The relative increase in length and width of the

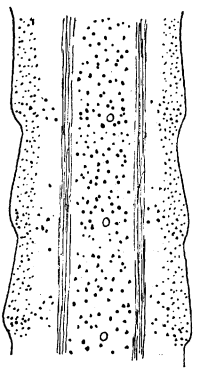


FIG. 71.

proglottid is considerably greater than its increase in thickness. The folds forming the posterior borders of the proglottids are formed by the localized growth of the peripheral parenchyma, and since growth begins here considerably later than in the central parenchyma, these folds are comparatively late in making their appearance.

(*To be continued.*)